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DEVELOP AN X-WINDOWS TOOL TO COMPUTE GAUSSIAN BEAM SYNTHETIC SEISMOGRAMS

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13. ABSTRACT *(Maximum 200 words)*

This report contains a description of progress made on the design of an X-Windows package for computing synthetic seismograms using the Gaussian Beam method. A summary of the functional flow and the basic architecture of the system formed the bulk of the first semiannual report for this project. Development has now reached the point that the user can create synthetic seismograms for two-dimensional velocity models created with the X-Windows interface. A module called Xgb is used to form and shape the two-dimensional velocity models and to trace rays through the medium. A second module, called GBseis, reads the raytracing results created by Xgb and computes synthetic seismograms according to instructions passed to it via interprocess communication (IPC) messages from Xgb. The IPC software and the code to view the results of the synthetic seismogram computation have all been developed previously under the NMRD. A final major step yet to be done is to incorporate SQL queries into the code to allow raytracing results and velocity models to be stored within an Oracle database like that which exists within the software environment at the Center for Seismic Studies.

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1. OBJECTIVES

The principal objective of this project is to create an X-Windows-based graphics tool to compute rapidly and efficiently, synthetic seismograms for laterally heterogeneous, two-dimensional, isotropic velocity models using the Gaussian beam method. The existing Gaussian beam software is written in Fortran code and can be very labor intensive to use. Our goal is to construct an X-Windows Graphical User Interface (GUI) which will eliminate much of the tedium of introducing lateral heterogeneity into two-dimensional velocity models.

This report contains a description of progress made on the design during the past six months. A summary of the functional flow and the basic architecture of the system formed the bulk of the first semiannual report for this project. Included here is a list of what remains to be done before completion.

2. CURRENT STATE OF DEVELOPMENT

During the past six months, the two programs which constitute a new system to compute synthetic seismograms have undergone rapid development. *Xgb*, the X-Window interface, is now fully capable of displaying velocity models in two dimensions, allowing the user to modify those models through graphical tools, and tracing rays through the velocity model for later use in seismogram computation or traveltime queries. *Xgb* exchanges information via interprocess communication (IPC) messages with a second module, *GBseis*, that actually performs the seismogram computation and responds to traveltime queries. *Xgb* also exchanges IPC messages with *geotool* that allows the user to set the channels, time scale and origin parameters to be synthesized. A working version of this package was demonstrated at the 14th Annual Phillips Lab/DARPA Symposium Sept 16-18, 1992, in Tucson.

One way of outlining the current capabilities is to describe how a typical *Xgb* session would proceed. The user initiates the program *Xgb* to construct a 2-D velocity model or read in one already created in an earlier session. The former case is illustrated here. The user presses a button, and the display shown in Figure 1 appears. A number of regional and global 1-D starting models are available from which the user may choose. The 1-D global model selection **jb** (for Jeffreys-Bullen) is highlighted in inverse video, and v_p, v_s, and ρ appropriate for JB are plotted on the right. Once a model is selected, the graphs of v_p, v_s and ρ are updated accordingly. The vertical dimension of the space to be modeled extends from the free surface to a depth controlled by the horizontal line segment shown on each of the three functions. The line may be slid vertically by the mouse or, alternatively, the bottom depth may be entered into the space labeled "Depth" at the lower left. By setting a minimum lower depth and the number of horizontal knots (at the lower right), one can control model size and therefore performance speed. The breadth of the model is controlled by entering the maximum number of degrees (or kilometers for regional models) in the bottom center window.

Figure 2 shows the result of specifying the starting model of Figure 1, placing a source at 350 km depth, and then plotting rays for *P*, *pP* and *PcP*. Symbols representing

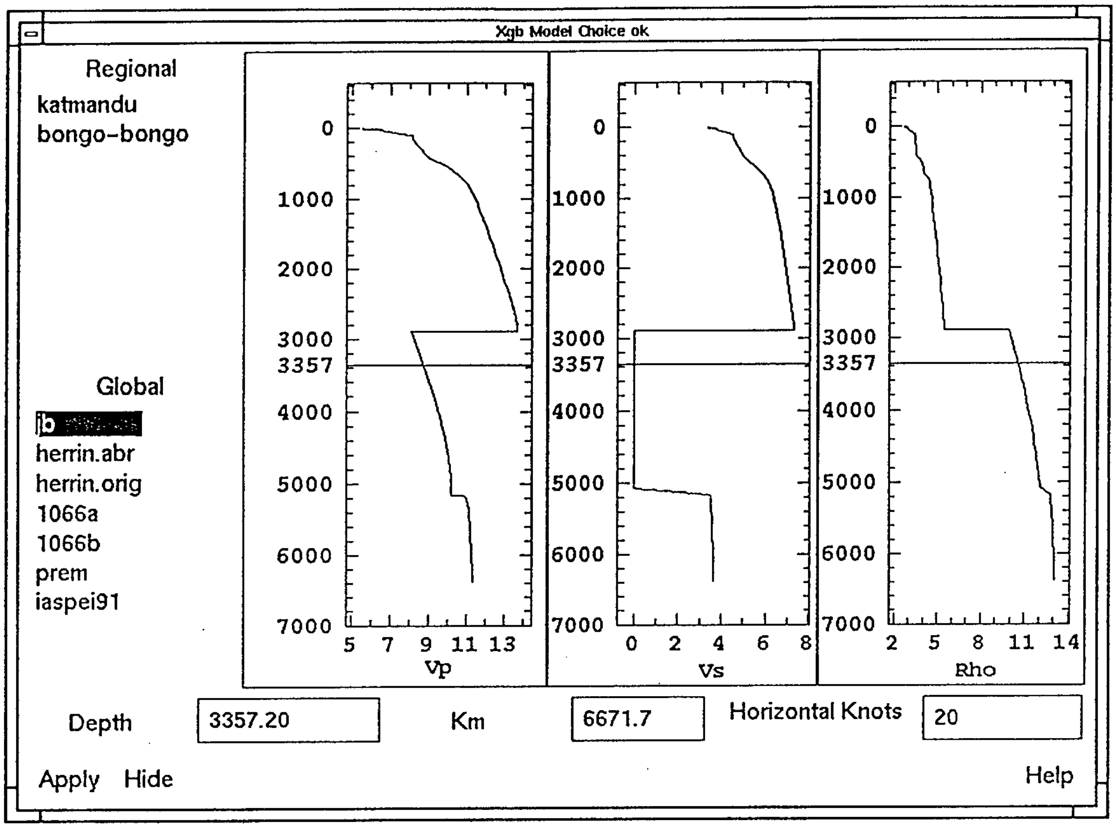

Figure 1

the position of two receivers at x=4000 and x=4200 km respectively can just be seen. The results of dynamic raytracing have been preserved for later use by *GBseis* in a disk file. Should the user now wish to alter the model, this may be accomplished by "grabbing" a knotpoint at the vertices of the model triangles and translating it through space. Because velocity is linearly interpolated between model knotpoints, this translation changes the velocity gradient in all adjacent triangles. After the model is altered, rays are rapidly retraced through the new model.

Having completed the raytracing, the user initiates seismogram computation with the *Xgb* window pictured in Figure 3. There are a number of buttons in this window which allow the user to adjust the parameters used in seismogram computation. Elements in the upper left control how Gaussian beams will be summed by *GBseis* and what type of source will be employed. Epsilon, the Gaussian beam parameter, allows the user to alter how the program sets or computes the widths of the beams. The numbering scheme followed here is governed by the convention outlined in *Weber* (1988). The user has a choice of treating the medium as elastic or taking attenuation into account. The toggle is here set to the anelastic case. Finally for source type, one may choose between a point

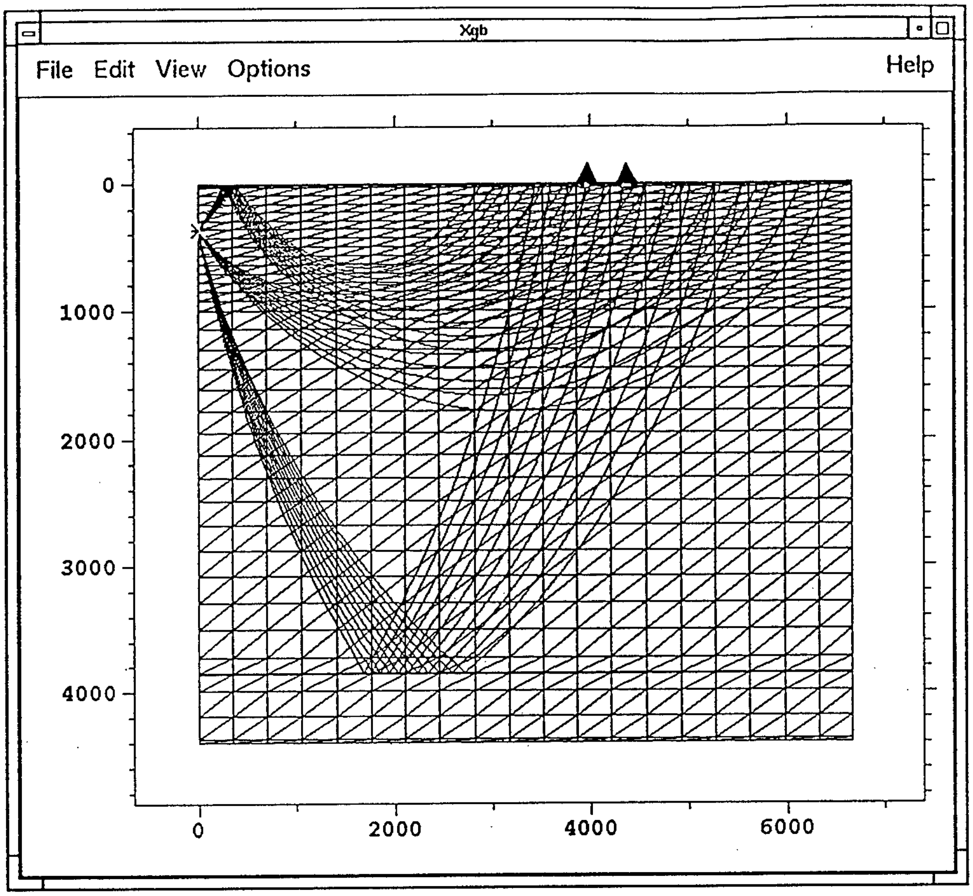

Figure 2

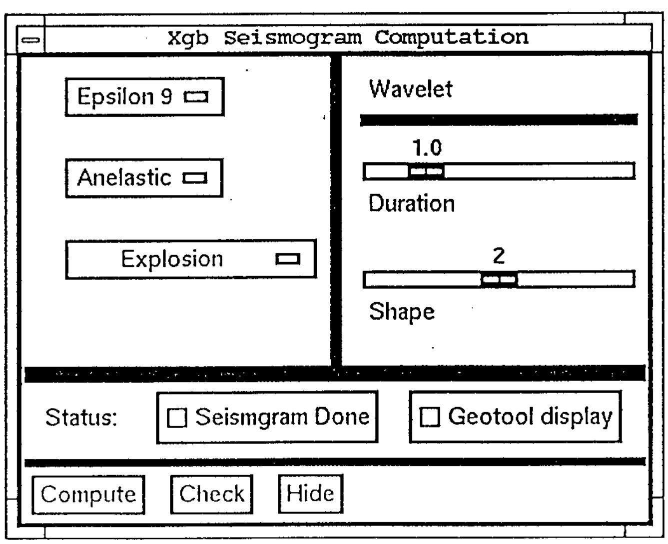

Figure 3

source (explosion), line source, or double couple. If the latter, the user may adjust the focal mechanism orientation through a popup containing sliders. On the right are sliders which control the source-time function. At this stage of development, the only source-time function used by the program is the Küpper signal defined by its period (duration) and number of zero crossings (shape).

Once the user has chosen the parameters, he pushes the "Compute" button at the bottom, and an IPC message containing these parameters is sent to *GBseis*, which has been running quietly in background all of this time. *GBseis* performs the computation, writes the results onto disk in CSS 3.0 format, and returns an IPC message to *Xgb* informing it that the computation is complete, or if an error has occurred, what that error was. If successful, *Xgb* sends a different message to *geotool* informing it where the waveform files are located on disk. Otherwise, *Xgb* brings up a text window containing a terse explanation of why the computation failed.

Figure 4 illustrates a *geotool* display in response to receiving an IPC message from *Xgb*. The three phases are plainly visible on both the vertical and radial components for both stations. Should the user wish to change the wavelet shape or source type, he need only adjust the display in Figure 3 and depress the "Compute" button once again. The time required to exchange IPC messages, compute the seismograms, and display the results is on the order of 10s or less.

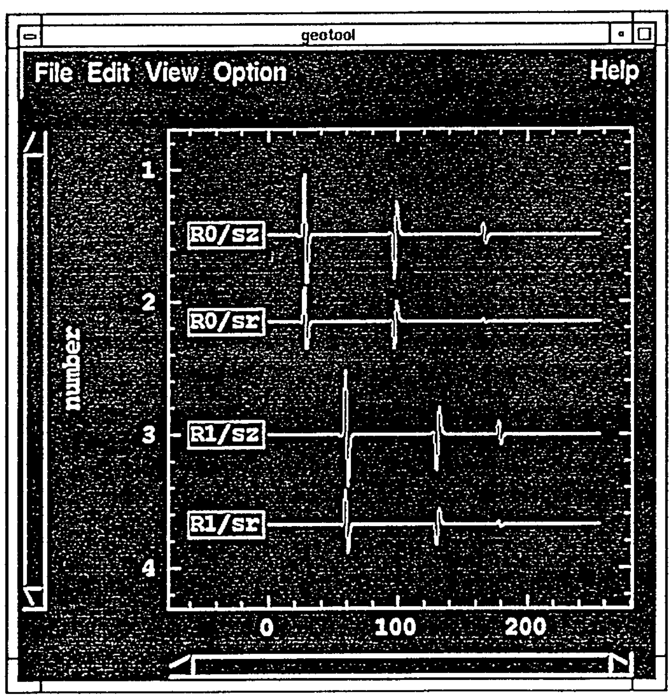

Figure 4

3. POST-TUCSON IMPROVEMENTS

Two of the shortcomings evident in the version showed at the Tucson meeting have been addressed since that time. The user may now input a source-time function from a file and substitute it for the Küpper signal used previously. The graphics of Figure 3 are being updated to reflect this change.

More importantly, selection of phases to include in the seismogram is now much easier than before. Figure 5 illustrates the selection list now available to the user. To include a phase, it is only necessary to click on its name in the list. Not apparent from this illustration is the use of color in the actual display. Legs of rays run as P or S waves are shown in contrasting red or blue.

Less apparent at Tucson was *GBseis*'s inability to generate a transverse trace. This has been addressed in the *GBseis* code, but there remain some refinements in the way *Xgb* records the raytracing results before this capability is fully realized.

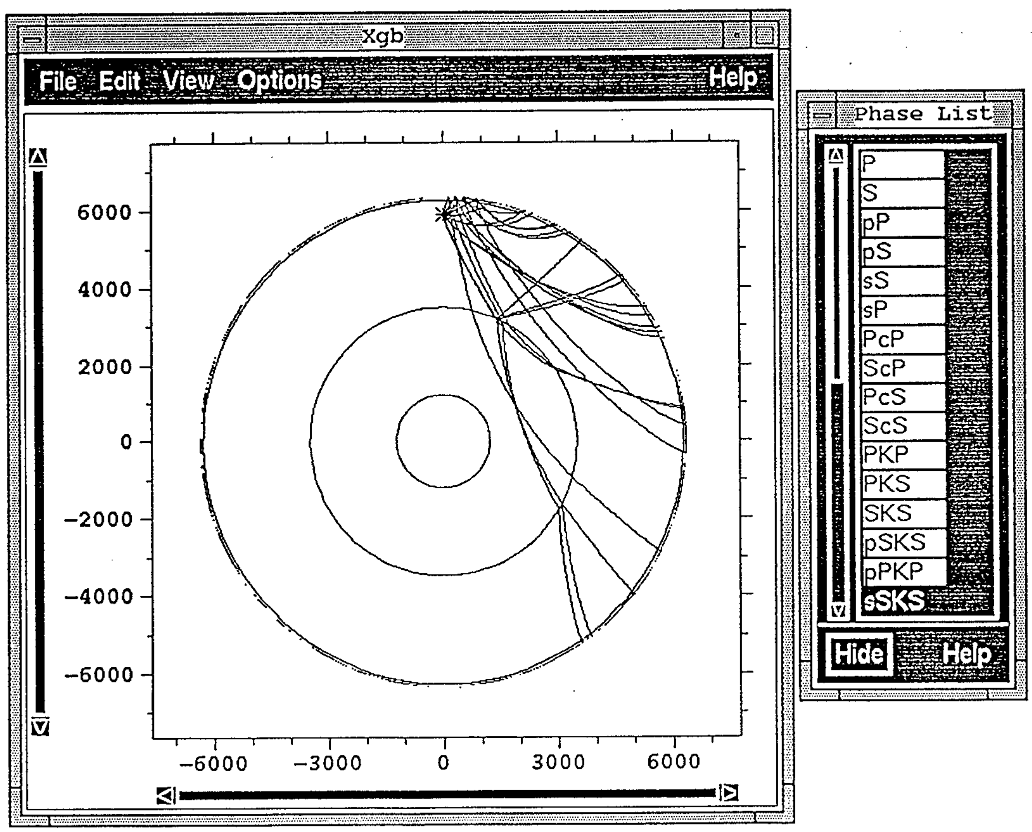

Figure 5

4. REMAINING TASKS

The chief software engineering task which remains is to embed SQL queries within the C code. It is our intention to build the model lists in the window of Figure 1 by referring to information stored in the CSS Oracle database. Likewise, we wish to store the locations of 2-D models and the raytracing results corresponding to these models in the database for future reference by researchers of the IMS. Because some high-level routines for accomplishing just these tasks have already been created through the NMRD, this is not a daunting task, but as in all programming, it will require paying attention to detail.

As time permits, we will work further on that part of *Xgb* which allows the user to manipulate the model. There is a clear need to let the user modify the velocity *at a knotpoint* rather than simply allowing him to translate the knotpoint through space. Also, one would wish to alter the properties of groups of knotpoints.

Considerable progress has been made in porting the code to Teledyne's new IRIS Crimson Elan machine. The software development tools provided with the Crimson should accelerate the remainder of work to be done for this project.

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